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SENNA ALATA EXTRACT MODIFIED PULLULAN AS BIO COAGULANT IN WATER TREATMENT

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ABSTRACT

The production of drinking water from raw water sources involves coagulant use at a coagulation/flocculation stage, to remove turbidity in the form of suspended and colloidal material. Many coagulants and flocculants are widely used in conventional water treatment processes. Aluminum and ferric salts can be classified as inorganic coagulants while polyacryl amide derivatives and polyethylene imine falls in the category of synthetic organic polymers. Currently, the conventional water treatment processes use inorganic coagulants such as aluminum polychloride and aluminum sulfate for the coagulation/flocculation processes. However, studies show that the usage of the inorganic coagulant causes serious damage to the human health. In the current study, the effectiveness of Pullulan and extract of Senna Alata as bio coagulant for water treatment was explored as an alternative material for the conventional coagulant for water treatment. Senna alata leaves were extracted by using the water extraction method. The bio coagulant of Pullulan and Senna Alata extract s were prepared at different mixing ratios. The effectiveness of bio coagulant was determined through assessments on the treated water quality in terms of turbidity, pH, and dissolved oxygen. The effectiveness of the Pullulan and Senna Alata extract as bio coagulant for water treatment was shown to be more efficient compared to treatment using conventional chemicals.

KEYWORDS: Water Treatment, Bio Coagulant, Pullulan & Senna Alata

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Original Article

INTRODUCTION

Water is essential for human survival. Total amount of water in the world is reported to be around 1400 $x10^6$ km^3 which is equals to 10^8 tonnes. Out of this volume, 97% is seawater, and balance 3% is ground water. Water used for drinking should be toxic less, pathogenic free, colorless and odorless. Cheesbrough reported that waste water discharged into other water sources eventually contaminates and pollutes it. Waste water been treated to remove the turbidity, microbiological pollutants and chemicals that may cause health hazards [1].

Textile and dye industries contribute to high environmental impact, since it produces highly polluted or colored waste water. Waste water from textiles or dye industry is treated through biological, chemical or combination of both. Chemical processes are largely effective and utilized well in waste water treatment plant compared to treatment through biological process. Alum, Polyaluminumchloride (PAC), ferric chloride is conventional chemical coagulants, which are widely used for waste water treatment. The disadvantages of using conventional coagulant include high operation cost, large sludge volume and significant effect of pH of the waste water. Thus, it is important to develop coagulants that are environment friendly and affordable through biological

method or aerobic treatment [2]. Research attraction is currently based on bio coagulant development either from plant or animal tissue which gives stable performance for waste water treatment, which is also biodegradable and harmless to human health to overcome the disadvantages [3].

Pullulan is a type of microbial polysaccharide, which is water soluble [4]. Pullulan is produced by fungus like yeast called *Aureobasidiumpullulans.* Recent studies conducted in the polysaccharide field revealed that pullulan is one of the unique polysaccharides, as it has variety of potential industrial and medical application functions. The elastic property and thermal stability of pullulan creates greater opportunity for it to be utilized in many ways and industries.

A study was conducted by Saber-Samandari and Gulcan [5] on efficient removal of anionic and cationic dyes from an aqueous solution using pullulan-graft-polyacrylamides porous hydrogel. The new porous hydrogel was able to take up the methylene blue (MB), cationic and reactive blue 2 (RB), anionic dye from the aqueous solution. The newly synthesized hydrogel has high capacity of dye absorbent

Senna Alata (SA) is an ornamental shrub belongs to Ceasalpiniaceae family. It can be found at West Africa forest areas [6]. These leaves are used for treatment of certain infections. The antimicrobial activity of the plant is observed to be associated with the presence of several chemicals such as tannis, phenols, saponins, alkaloids, steroids, flavonoids and carbohydrates

To the best of our knowledge, no literature was found incorporating of pullulan with *Senna alata* extract as biocoagulant in water treatment. Thus, the potential of *Senna alata* extract modified pullulan as biocoagulant upon water treatment were investigated. The treated water quality was analyzed in term of turbidity, pH and dissolved oxygen (DO). The biocoagulant was expected to provide an alternative to conventional chemical-based coagulants (alum) due to its natural-origin, biodegradability, non-toxicity and, concurrently reduce the volume of sludge production.

LITERATURE REVIEW

A turbid liquid with smell is known as waste with composition from smaller suspended solids to larger floating solids [7]. Normally, waste water contains pathogenic organisms, non-biological substance and also colloidal form solids pollutants.

Coagulation

Removal of colloidal and turbidity in the form of suspended materials requires coagulants. Coagulants that are mainly used are aluminum and ferric salts. Whereby, these chemical coagulants are not safe for human health. Research attraction currently is based on bio coagulant development either from plant or animal tissue which are biodegradable and harmless for human health. Bio coagulants also generate the least sludge [3]. In conventional water treatment plant, many coagulants are commonly used to remove the turbidity in form of suspended and colloidal material. However, conventional coagulants commonly used are chemical based, typically metal formulated (alum) has raised a number of concerns including eco-toxicological impacts when introduce to environment as post treatment sludge, impact on human health such as development of Alzheimer's disease. Thus, there is a need to design and develop alternative coagulant to replace chemical based coagulant in water treatment. Most of current researches had focus on the development of biocoagulant as alternatives material for water treatment to enhance the quality of the treated water as well as to improve the health's condition of human simultaneously, simplified the treatment process as well as to lower down the total treatment cost. Plant-based coagulant is one of the appropriate solutions to produce safe potable water compared

to conventional coagulant.

Biopolymers

Biopolymers are degradable and can be broken down by the action of organisms that gives CO_2 and H_2O as by-product which is environmentally safe. Though, demand for more complex hydrocarbon from fungi and bacteria, especially in polysaccharides such as xanthene and pullulan has been increasing [8].

Study on Chitosan derivatives obtained by chemical modifications for biomedical and environmental applications were conducted by Alves [9]. In this study, chemical modification was made on Chitosan by introduction of certain small functional groups to the Chitosan structure. The grafted chitosan is soluble in all, acidic, neutral and basic aqueous solution and it's observed that existing derivatives of chitosan makes it safe to be used in waste water treatment.

Pullulan

Pullulan is non-ionic polysaccharide (non-plant based), which can act as natural coagulant. Pullulan is used to improve the coagulation/flocculation process in water treatment due to their excellent adsorption behavior [4]. In addition, pullulan is non-toxic, non-immunogenic, non-carcinogenic and non-mutagenic which does not give adverse effect to human's health. It is a promising material for variety of applications such as packaging, cosmetic emulsions, coating and biomedical uses due to its biodegradable polymer properties, impermeable to oxygen, non-toxigenic and non-carcinogenic [5]. According to Bishwambhar Mishra [14], to produce colloidal drug delivery formulations of nanoparticles, this is specifically pH sensitive.

Senna Alata

An ornamental shrub, which grows well in forest areas of West Africa's, is known as *Senna Alata*. A study was carried to identify the antifungal and antibacterial activities of an alcoholic extract of *Senna Alata* leaves. Based on this study, it was determined that the extract of crude methanolic was able to inhibit the growth of organisms except Candida albicans and Saccharomyces [10]. A study reported by Aweng E.R. et al. [13] proved that Cassia alata or also known as *Senna alata* as natural coagulant able to reduce river water turbidity up to 93.33%. Further testing on SA, shows that it has significant antimicrobial effect against Gram positive bacteria and fungi.

Bio Coagulant

Based on a study conducted by K. Qureshi et al [3] on the development of bio coagulant from mango pit for the purification of turbid water, it was found that mango pit extract as bio coagulant are effective for turbid water treatment. This bio coagulant does not give any harmful effect for human health. It was observed that the mango pit extract helped to remove the water turbidity up to 98% at the use of optimized dose which was up to 0.5ml/liter.

Another study was conducted to explore the use of cactus *Opuntiaficusindica* (OFIP) in the bio coagulation and flocculation of Pb (II) ions from wastewaters. From this study, it was found that coagulation and flocculation process are affected by pH and dosage of OFIP. The optimum pH was found to be 5 while the optimum dosage is 8mg/L. As the dosage of OFIP increase, the zeta potential of OFIP-Pb (II) was found to decrease and at dosage 8mg/L the charge occurred to be zero. The process of coagulation and flocculation was the most effective when the OFIP used has a particle size of <75 μm. Through this study, it was proven that OFIP is an effective bio coagulant of Pb (II) ions [11].

METHODOLOGY

Part A: Sample Preparation

Senna Alata samples were collected. The collected leaves were dried in oven at 50°C for two days. The leaves were then grounded using grinder. The grinded materials were then passed through sieve, 0.4mm.

Raw surface water for this study will be collected from Muar River. The water from river was collected by immersing a plastic container, which was washed with nitric acid as a sterilization measure.

Part B: Extraction

The crude extract was prepared by adding 1L of distilled water into 50g of powder prepared using *Senna Alata* leaves. The mixture was then mixed using a magnetic stirrer for about 60 minutes and left for 20 minutes for settling down process. The extract was filtered using filter paper.

Part C: Bio Coagulant Preparation

Firstly, 6g of Pullulan was dispersed in 200ml of distilled water and 1.5g glycerol. Then, pullulan solution and the crude extract were mixed with different mixing ratios as shown in Table 1 below. The solution was then gently mixed by stirring with a magnetic bar until the solution is homogeneous. The dosage used of bio coagulant used was fixed at 0.6 g/L. This is based on the study reported by Duithy George et al. [15] where the optimum water quality parameters obtained at dosage 0.6 g/L.

Table 1: Percent Composition of *Senna Alata* Extract, Pullulan Mixture and Bio Coagulant Dosage

Senna Alata Extract (%)	Pullulan (%)	Bio Coagulant Dosage (g/L)
0	0	0.6
0	100	
100	0	
5	95	
10	90	
20	80	

Part D: Evaluation of coagulation performance at different coagulant dosage

Jar test was carried using 1L beakers. Six beakers were filled with 300mL of water. The prepared bio coagulant was added into the water sample based on the ratio as in table 1. The solution was then mixed at 200rpm for 3 minutes using magnetic stirrer and subsequently at 80rpm for 30 minutes for flocculation purposes. 100mL of sample from the treated water was taken out after 20 minutes of settling to determine the pH, Dissolved Oxygen (DO), turbidity.

RESULTS AND DISCUSSIONS

Analysis of Turbidity

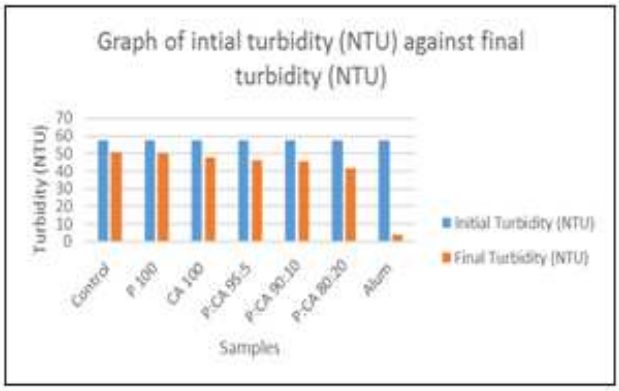

Figure 1: Graph of Initial Turbidity Against Final Turbidity

Based on the Figure 1 above, it can be seen that with addition of pullulan and *senna alata*, there is slight reduction in the final turbidity reading after coagulation-flocculation process compared to the initial reading and control. The highest turbidity value recorded for control, 50.97 NTU and lowest turbidity recorder for Alum, 3.81 NTU and followed by P:CA 80:20, 41.97 NTU. However, the turbidity shows a constant reduction with addition of *sennaalata* modified pullulan and the highest reduction observed at the mixing of Pullulan, *sennaalata* at ratio of 80:20. As the ratio of *sennaalata* increase, the reduction of turbidity becomes higher. This may be due to when coagulant added to waste water and stirred rapidly, the resulting cationic protein from plant extract. In the current study, *Senna alata*, will be distributed to all parts of liquids and then interact with the negatively charged particles that causes the turbidity dispersed. This interaction disturbs the force that stabilizes the particles and it binds to small particles to form flocs. This reaction was proved in the study of the use of Moringa Oleifera Seed Powder as Coagulant to Improve the Quality of Waste water and Groundwater conducted by Hendrawati et al,[16]. However, comparing to the reduction of water turbidity by conventional coagulant, Alum, the reduction by *Senna alata* modified Pullulan, is not significant.

pH Analysis of Treated Water

Figure 2 below shows the pH of treated water using bio coagulants at different ratio and conventional coagulant alum.

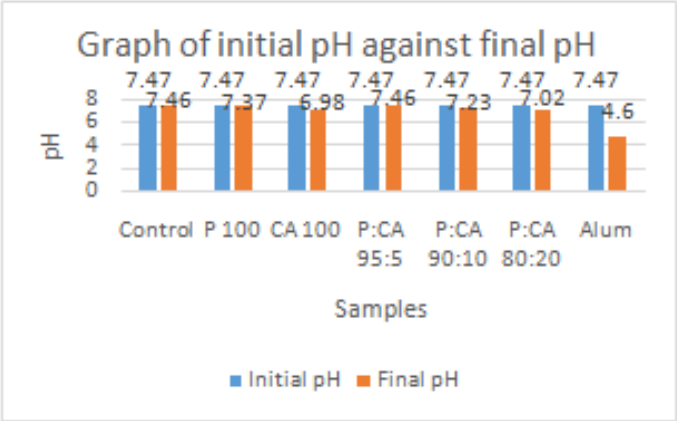

Figure 2: Graph of Initial pH against Final pH of Treated Water

Based on the graph, it can be observed that, the *sennaalata* and combination of pullulan, *sennaalata* at ratio 80:20 is able to reduce the pH to a significant level, but still within the acceptance range with pH 6.5 to pH 8.5 for water supply for conventional use. Thus, there is no need to adjust the pH of treated water before releasing to the domestic usage. But, as for alum coagulant, the pH dropped to 4.6, acidic. This is due to during the treatment process, acid is produced by alum. According to J.P. Sutherland et al; [12], acidity of the treated water increased due to acceptance of lone pair electron by the aluminum trivalent cation that acts as Lewis acid. Thus, *sennaalata* modified by pullulan act as a good bio coagulant to maintain the pH.

Dissolved Oxygen

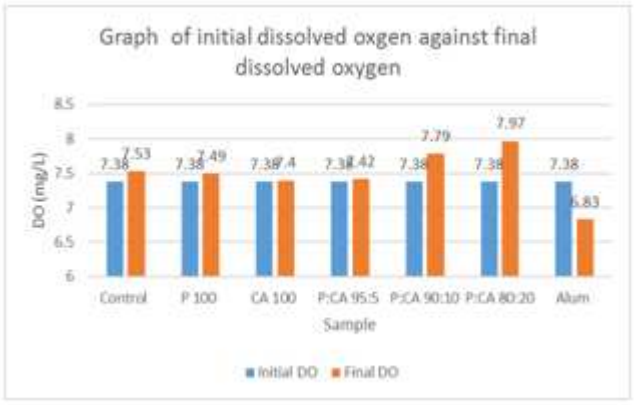

Figure 4.3: Graph of Initial Dissolved Oxygen Against Final Dissolved Oxygen

From the figure 4.3, it can be seen that the bio coagulants are able to increase the oxygen content in the treated water. It is also observed that the mixture of pullulan, *sennaalata* at ratio 80:20 is able to increase the DO up to 7.97 mg/L compared to the initial DO of 7.38 mg/L. In addition to that, comparing to conventional coagulant alum, the DO of water treated using alum reduced to 6.83mg/L. Thus, the bio coagulant is effective in increasing the oxygen concentration in the treated water.

CONCLUSIONS

The *sennaalata* extract modified pullulan has shown its performance as bio coagulant. The bio coagulant has shown reduction in turbidity for all the mixing ratios and significant reduction of 26.76% were observed for pullulan *sennaalata* mixture at ratio 80:20. The pH water treated using bio coagulant remained in the range of 6.5 to 7, and hence there were no additional pH adjustment needed. Pullulan *sennaalata* mixture at ratio 80:20 is able to increase the DO up to 7.97mg/L. As the composition of *Senna alata* increased, the bio coagulant performance observed to be better.

Thus, the mixture of Pullulan and *Senna alata* has the potential to be used as bio coagulant in water treatment.

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